

ANGIOTRIPSY AS A SUBSTITUTE FOR THE LIGATION IN ROUTINE WORK OF GENERAL SURGERY.¹

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As recently as 1896, a new method was given to the profession by Doyen, in the presentation of the angiotribe, or "pince à pression progressive," as he called the instrument, which he employed in the compression of the broad ligaments or the pedicles of tumors. This was to replace the method of compression by clamps, which had to remain *in situ* for twenty-four to forty-eight hours, the angiotribe accomplishing the same results in two to five minutes. Tuffier, Thumin, and others have improved the original instrument. I have also heard that Bissel, of New York, arrived at the same idea almost simultaneously with Doyen, but have not been able either to see or secure the instrument he devised.

However many advocates the angiotribe has to-day among gynaecologists,—although, because of its cumbrousness, they are few in number,—it is rarely, if ever, employed in general surgery. This is doubtless due to the same objection, and also to the ready application of the ligature in general surgery. While the gynaecologist has felt the necessity of something to simplify and render easier the "technique" of hysterectomies, and also to do away with secondary haemorrhages from the slipping of ligatures, in infiltrated tissues, or tissues containing many vessels of small size, like the broad ligaments and the pedicles of tumors, the surgeon has become so confident in his ligature

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that he has not felt the need of anything to replace it. He has not made use of angiotripsy, since in the angiotribe he has but an awkward substitute for the ligature. Its weight on an isolated vessel, even if supported, rather increases the liability to tear the thinned-out tissues.

The use of the angiotribe, however, has forced recognition of these facts: that forcible compression of the blood-vessels or sealing them by compression (which would appear to be a more correct term than "crushing") goes far towards rendering the work of the surgeon more expeditious; that it obviates the dangers of infection by ligature, either imperfectly sterilized or secondarily infected by repeated handling or from secondary wound infection.

If, therefore, the advantages of the angiotribe can be retained by any process, and its disadvantages removed or minimized, has not a distinct advance been made?

Pursuing investigations in this direction, for the last two years I employed the ordinary haemostatic forceps, with supplemental pressure supplied by a forceps improvised from a dental forceps. I used this on vessels of small size, with varying success, not entirely satisfactory, until the present stage of improvement in my experiments and operations had been attained. The simplicity of the procedure, in its present form, should prompt its adoption by the surgeon.

The perfected instruments which I have used in my experiments, and also in my recent operations (and for which I am greatly indebted to the ingenuity of R. Hoppe, instrument maker), consist of a haemostatic forceps and a pressure forceps of 1000 pounds to give supplemental pressure to the former. The haemostatic forceps I employ (Fig. 1) has a larger and broader snout than ordinarily, not tapering, permitting it to compress the tissues squarely and to equalize the pressure. The inner surface of one blade shows fine, shallow serrations in the steel, while the other blade shows a lining of alloy, with serrations moulded by pressure, the one surface fitting exactly into the other. This has been found to answer the purpose

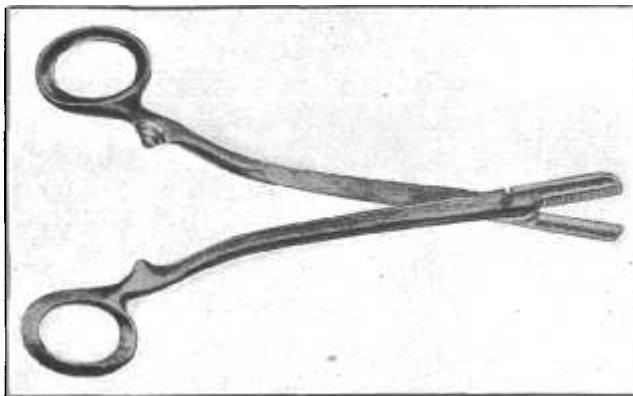


FIG. 1.—Hæmostatic forceps (one-half actual size).

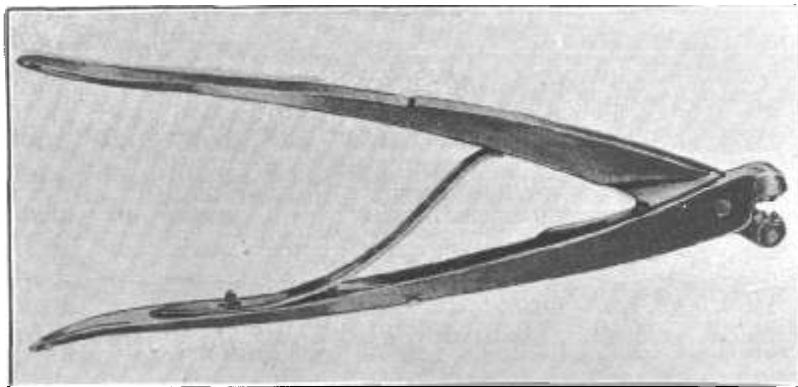


FIG. 2.—Pressure forceps (one-third actual size).

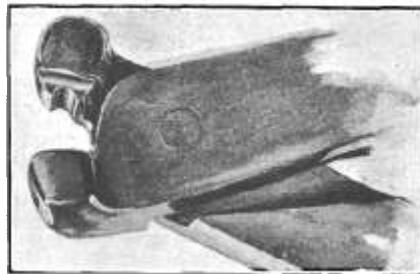


FIG. 2a.—Showing serrations of pressure forceps (actual size).

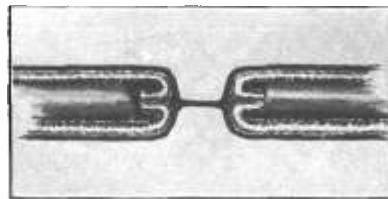


FIG. 3.—Section of artery, showing immediate result of angiotripsy.

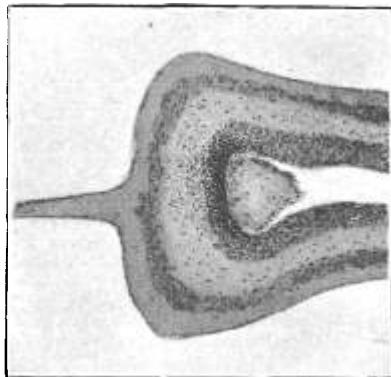


FIG. 4.—Posterior tibial artery of dog, killed eleven days after angiotripsy.

better than steel upon steel. The latter has a tendency to cut through, because the slightest variation of surface has been found to lacerate the tissues. The pressure forceps (Fig. 2) I employ must of necessity be large and heavy to exert such high pressure by direct force. It is a powerful forceps, thirty-two centimetres long, the lock only one and one-half centimetres from the blades, which are grooved in both transverse and longitudinal direction for receiving and steadyng the hæmostatic forceps (Fig. 2a). Of simple construction, it answers fully all requirements of strict asepsis. It has no more title to elegance than the angiotribe in its most recent modification, but a shorter handle or lighter construction would require much more manual force, and make the hand of the operator unsteady, thereby making likely or actually causing laceration of the vessel.

I am not alone in my efforts to simplify the angiotribe for use in routine surgery. A. Schulte has recommended a hæmostatic forceps with a short snout and a leverage on the handles five times the distance of the snout from the lock. Zweifel makes use of the toggle-joint. The latter does not answer the requirements of asepsis, and the water corroding the locks often renders the instrument unfit for use, and the screws break at a critical moment. Both the above methods are only applicable to small subcutaneous vessels, such as are divided in celiotomy or hernia operations, where most surgeons have found the ordinary hæmostatic forceps left *in situ* during the time of operation sufficient to accomplish perfect hæmostasis. The *modus operandi* in the latter case is different from angiotripsy, and hæmostasis is obtained by a clot forming without cutting the inner coats, simply holding them together by agglutination. In vessels of such small size, this answers the purpose, especially where secondary hæmorrhage is prevented, after the divided structures are united by sutures, which exert the pressure necessary to prevent reopening.

In applying this great pressure to arteries, it will be seen that the inner and middle coat are cut through and recoil, while

the outer serous coat is firmly compressed (Fig. 3). The watery elements being displaced, the two surfaces become firmly agglutinated.

In veins, the inner coats, being so much thinner, do not recoil, but are agglutinated in the same manner as in the arteries. On larger vessels, the haemostatic forceps should be left *in situ* for a few minutes after pressure has been applied. The length of time the pressure should be applied, and also the time the haemostatic forceps should remain *in situ*, will quickly suggest itself to the surgeon who uses angiotripsy as a routine practice. Care must be taken, however, in the use of the haemostatic forceps that it be applied at right angles to the axes of the vessels, so that it will not cut the inner coats obliquely. The instrument must also be held very steadily, as any twisting or pulling is apt to cause lacerations and consequent haemorrhage. In amputations or operations where Esmarch's constriction has been employed, the haemostatic forceps must be allowed to remain *in situ* until the circulation has been re-established.

The fact that after compression the forceps can remain attached as long as necessary, and not endanger haemorrhage from tearing by its own weight, should greatly enhance its value to members of the profession who have learned by experience the advantages of the angiotribe in pelvic and abdominal surgery.

In animal experiments I have made on the dog and sheep, I have had perfect results from compressing in this manner the radial, the brachial, the posterior tibial, the femoral, and branches of the mesenteric arteries. These arteries were selected on account of their easy access. In all cases except the mesenteric, though the incision was closed by sutures, the wound healed by granulation,—the animals licking the wounds and preventing healing by first intention. No secondary haemorrhages were encountered in any of the above experiments, though no bandages or immobilization were employed, and the animal was allowed to roam at large after the third day. The resulting scar tissue, firmly surrounding and embedding the

divided end of the arteries, made it rather difficult, after the animal had been killed, to dissect out the end of the vessel with the nicety desired to show the ribbon-like thinness and complete occlusion of the vessels.

The specimens show that the tissues thus treated are not devitalized and do not become necrosed, but are only powerfully compressed, the life of the cells not being destroyed.

Just as the angiotribe has been used in septic cases, this method may be employed where we deal with similar conditions in general surgery. A ligature in such cases, becoming infected, prolongs the process until it is cast off, only after a continued process of suppuration.

The microscopical examination of fresh specimens confirms the report of Thumin, who wrote, regarding the angiotribe, that the tissues are forcibly compressed without being destroyed. It will be seen that the cells are crowded and compressed, chiefly because of the squeezing out of the watery element and fat contained therein.

In the specimens obtained from dogs, after waiting until the time in which secondary haemorrhages could occur had elapsed, it was found that the process of healing is the same as in vessels tied with a ligature. The inner coats are perfectly united; a strong cell infiltration is seen where the two ends oppose each other. The outer coat in the ribbon-like continuation shows ordinary cell distribution. In the lumen of the vessel was observed the remnant of the organized blood-clot, not yet entirely absorbed (Fig. 4).

Without referring to the cases where I used the ordinary haemostatic forceps with supplemental pressure, I have used the more perfected instruments in routine practice, including four cases of amputation of the mammae, with clearing out of the axillæ, one Pirogoff amputation, two amputations of the lower part of the leg, one thyroidectomy, operations for removal of diseased cervical glands, and several partial amputations of the fingers. In none of these cases did I meet with secondary haemorrhage at any time after the operation.

One very important factor has impressed itself upon my mind, that sponging the parts in which vessels have been compressed by this method *must be done by direct pressure, and not by lateral friction over the surface*, inasmuch as such friction pulls on the vessels, and has a tendency to reopen the compressed end of the vessels and precipitate haemorrhage.

In the Pirogoff operation referred to above, I had to deal with a man aged fifty-eight years, who suffered from general arteriosclerosis. Feeling some anxiety in regard to a secondary haemorrhage, I introduced the sutures of the flap deep enough to bring additional pressure against the end of the artery, so that, even if the clot should be loosened and force open the agglutination of the end of the vessel, it could not be readily expelled. Recovery took place without the anticipated accident.

Since following this mode of procedure, especially in operations involving such a large area as amputation of the mammae, I have been particularly impressed, when removing the first dressing, with the comparatively small amount of wound secretion. A noteworthy feature in this operation was that I removed the drainage tube in the axillæ on the third day, and closed the aperture by secondary sutures introduced at the time of operating. Formerly, I did not change the dressing, unless indicated by the temperature curve, before the eighth day, when the drainage was removed and the wound allowed to heal by granulation. In all four cases, passive motions were made as early as the fifteenth day, the closed wound being protected by a light bandage, and the arm carried in a sling.

This can no doubt be explained not only by the absolutely perfect haemostasis which can be accomplished, arresting even the slightest oozing, but also by the absence of ligatures. The ligature when first introduced into the wound no doubt exercises an irritant action as a foreign body causing increase of the wound secretion, until the process of absorption, fully established, helps to dry the wound. This should be a great factor in inducing surgeons to use angiotripsy more exten-

sively, as it will in many instances render drainage obsolete, or, where this is impossible, considerably curtail the time necessary for its employment, as well as greatly lessening the chances of infection, by restricting secretion.

Another great advantage is observed, and that is that suffering is reduced to a minimum. The nerve filaments, often unavoidably enclosed in the ligature of an artery, cause a great deal of pain to the patient; this is especially observed in ligating the digital arteries. There is comparatively little pain when angiotripsy has been employed, as it crushes the nerve.

That pain is thus reduced to a minimum by reason of the complete crushing of the nerves has particularly impressed itself upon me in operations for haemorrhoids where I have employed angiotripsy instead of the clamp.

In extirpations of extensive cervical tubercular as well as carcinomatous glands I have not used a single ligature; and others to whom I have shown this method have achieved the same results.

In thyroidectomy, angiotripsy has rendered me excellent service, the isolated vessels being compressed in the usual manner, while the angiotribe was employed crushing through part of one lobe to be retained, and the isthmus.

While I have successfully used this method on animals, on as large a vessel as the femoral, I do not underestimate the danger, nor the responsibility of the surgeon, in using it on as proportionately large a vessel in man. A precautionary or supplementary ligature applied, after angiotripsy, to one or two such large vessels involved in so large an operation as high amputation would not lessen the advantages derived from the employment of angiotripsy, and the ligature necessary in such cases could be of such fineness that complete sterilization would leave no doubt as to perfect asepsis. It is also self-evident that in a friable organ, such as the liver or kidney, or in a sinus, like in the dura mater, angiotripsy is of no avail.

From the observations of men who have used the angiotribe more or less since its origin, and also from my own obser-

vation with the more improved instruments and their simplicity of application to general surgery, I am convinced that angiotripsy has a decided advantage, a large field of application, and has greatly enriched surgical technique.

I am especially indebted to Drs. E. S. Howard and J. R. Clark for their assistance rendered in my operations and in making the animal experiments, and also to Dr. J. M. Stowell for preparing the microscopical specimens.